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Regulatory Options for the Control of Odors

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Regulatory Options for the Control of Odors

by

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1.0 EXECUTIVE SUMMARY

1.1 Introduction

This report is the response of the Environmental Protection Agency (EPA) to Section 403(b) of the 1977 Clean Air Act Amendments (P.L. 95-95), which requires a study of the effects of odors and odorous emissions on public health and welfare and an analysis of strategies or authorities available or appropriate under the Clean Air Act for abating such emissions. The report is composed of two sections paralleling the twofold nature of Section 403(b). Under contract to EPA, the National Academy of Sciences prepared a study of

> "....the effects on public health and welfare of odors or odorous emissions, the sources of such emissions, the technology or other measures available for control of such emissions and the costs of such technology or measures, and the costs and benefits of alternative measures or strategies to abate such emissions."

On the basis of that report, EPA then prepared a second document (the present report), which contains

> "....an evaluation of whether air quality criteria or national ambient air quality standards should be published under the Clean Air Act for odors, and what other strategies or authorities under the Clean Air Act are available or appropriate for abating such emissions."

This EPA report also surveys current State and local odor regulations, evaluates the effectiveness of regulations similar in form to those that might be promulgated under the Clean Air Act, and then discusses the advantages and disadvantages of alternative Clean Air Act regulatory strategies. The NAS Study is summarized in the Appendix to the present report, and a complete copy of the NAS document accompanies this report.

1.2 Survey of State and Local Regulations

State and local regulations vary considerably but can be divided into nine general categories including:

- no specific regulation (i.e. common law)
- nuisance regulations
- emission standards
- ambient standards.

The nuisance approach remains the most widely employed strategy and virtually all regulatory programs continue to rely upon citizen complaints for enforcement purposes. Most agencies currently assign low priority to odors as a candidate for new federal regulation because of the great pressures produced by the revisions of state implementation plans (SIP's) mandated by the 1977 Clean Air Act Amendments and because odors are not perceived as a threat to public health. The combination of citizen/agency pressure and threatened legal action is generally sufficient to encourage problem sources to undertake voluntary compliance and abatement programs.

The majority of odor problems (as judged by citizen complaints) are attributable to a relatively small number of source categories (such as agricultural and livestock operations, diesel exhaust, incinerators, etc.). Thus, any regulatory strategy that might be devised should probably be focused on these source categories to maximize efficiency. Reactions to odor depend heavily, however, on local values and individual aesthetic judgments. The absence of any meaningful data that relate ambient odor levels (or odorant concentrations) to community annoyance levels will likely frustrate any attempts to establish general nationwide ambient odor regulations for the foreseeable future. Indeed, since odor perception is quite subjective, nuisance law, initiated by citizen complaints, appears to be an appropriate mechanism for dealing with odor problems.

1.3 Clean Air Act Regulatory Strategies

Under the Clean Air Act, there are basically four different regulatory strategies available for the control of odor pollution:

1. National Ambient Air Quality Standards (Sections 108-110)
2. New Source Performance Standards (Section 111)
3. National Emission Standards for Hazardous Air Pollutants (Section 112)
4. Motor Vehicle Emission Standards (Section 202).

Since a hazardous air pollutant is defined as one capable of causing or contributing to an increase in mortality or serious illness, Section 112 appears to be an inappropriate regulatory approach for odors. Thus, the available strategies are reduced to three, ambient standards (Section 108-110), stationary source emission standards (Section 111), and mobile source emission standards (Section 202). A 1978 statement of the Air Pollution Control Association Odor Committee (APCA TT4) well summarizes the essence of the problem of choosing between ambient and emission-based strategies:

> "Both approaches have strengths and weaknesses. The stack emission approach has obvious advantages over an ambient odor type regulation regarding the relative ease and lower costs of sampling and analyzing odors. Also, the emission source of objectionable odors is more readily determined by using stack measurements. However, the stack emission type approach requires an additional technical step - the correlation of stack emission with ambient odor concentration, either by obtaining empirical data or by use of atmospheric dispersion models, in order to be able to judge whether or not the resulting ambient odor concentration is acceptable to the community.
>
> On the other hand, if odor annoyance threshold data are available, an ambient odor limit can be related to a particular zoned area and specified to avoid an odor annoyance being experienced by the population that lives or works in a particular zoned area. Further, it should be recognized that odors do not discharge only from stacks or well-defined enclosures but could originate from fugutive type emissions (i.e. anaerobic lagoons). As a result, it may be necessary in certain areas to have a combination of stack emission and ambient odor regulations available to control all significant sources of odor."

While emission standards appear to offer more promise than ambient standards as a federal odor control strategy, technical difficulties still

exist. The fundamental problem is that application of best available control technology does not guarantee that community odor annoyance levels will not be exceeded. This problem becomes even more complicated when fugitive odor sources such as lagoons are involved or when multiple odor sources are located in close proximity to one another. These problems make it nearly impossible to predict the odor reduction potential of any given abatement program.

1.4 Recommendations

Although there are problems inherent in any regulatory control program for odors, there are a number of specific recommendations which could improve the effectiveness of these regulations:

1. The existence of a community odor nuisance should be established before limits are applied to a specific odor source.

2. The relationship between ambient odor levels (or odorant concentrations) and odor annoyance thresholds for different communities or zoned areas must be determined prior to establishing ambient odor type standards. This step might be accomplished by determining both the dose-response relationships that equate community annoyance with odor intensity and the degree of unpleasant character of a particular odor. However, for some odorants such relationsips may be impossible to develop.

3. The Scentometer and ASTM syringe methods currently used by state and local agencies are considered to be inadequate for regulatory purposes. There is a basic need for odor sensory methods that are capable of measuring odors objectively and reliably, the results of which can be related to community annoyance.

1.5 Conclusions

In conclusion, federal regulatory involvement in odor control does not appear to be warranted. This conclusion is based on the following considerations:

1. Odors are not caused by a single pollutant, but rather are a subjective effect which may result from different combinations of numerous odorants. Thus, it is very difficult to associate any specific health or welfare effect to a given "odor concentration". As a result, the available data are not sufficient to support the establishment of a primary or secondary ambient air quality standard for odors.

2. Other problems which limit or preclude setting of national ambient air quality standards for odors or developing State Implementation Plans for odors include:

   a. Techniques used to measure odors are considered generally inadequate for regulatory purposes.

   b. Reliable procedures for relating ambient odor levels to the extent of community annoyance do not exist.

   c. Community tolerances or odor annoyance levels vary widely.

3. Use of best control technology for new or existing sources of odors under section 111 of the Act also has problems:

   a. It would require best controls nationwide, even though a source type may be a problem only in certain areas or situations.

   b. It does not guarantee that community odor annoyance levels will not be exceeded, especially where fugitive odor sources are involved or when multiple odor sources are located in close proximity to one another.

   c. Assessing and/or regulating all odor source categories would require an inordinate expenditure of Federal, State, and local control agency resources which are already fully extended to meet other Clean Air Act requirements.

4. Local and state odor control procedures appear to be generally adequate and are probably more cost effective than a uniform national regulatory program under the Clean Air Act.

2.0 INTRODUCTION

This report is submitted in response to Section 403(b) of the 1977 Clean Air Act Amendments (P.L. 95-95). That section required the EPA to study and report to Congress on the technical and regulatory dimensions of odor control.

This report consists of two sections

Section 1. The effects on public health and welfare of odors and odorous emissions, the sources of such emissions, available control technologies or methodologies, together with associated costs, and the costs and benefits of alternative abatement strategies.

Section 2. An evaluation of whether air quality criteria or national ambient air quality standards should be published for odors under the Clean Air Act, and an evaluation of what other Clean Air Act strategies or authorities are available or appropriate for abating odor emissions.

Section 1 has been prepared for EPA by the National Academy of Sciences[1] and is attached to this document.

Section 2 consists of several parts:

- A survey of current State and local odor control regulations;
- An evaluation of the effectiveness of selected State and local odor control regulations most similar in form to regulations that could be promulgated under the Clean Air Act;
- An analysis of the advantages and disadvantages of the three basic regulatory options (NAAQS, NSPS, NESHAP) for controlling odors available for federal use under the Clean Air Act.

3.0 SURVEY OF ODOR REGULATIONS

From a conceptual standpoint, existing State and local odor control regulations can be divided into nine general categories. A 1974 odor regulation survey of all state and selected local air pollution control agencies was published in the May, 1974 edition of the Journal of the Air Pollution Control Association using this nine-category format.[3] EPA has updated this 1974 survey, the results of which are summarized in Table 1.[4] The regulatory categories include:

1. No Specific Regulation - Although many jurisdictions have no specific odor control regulation, common law public or private nuisance continues as an available remedy for odor pollution problems.
2. Nuisance Regulation - These regulations codify the traditional nuisance concept, enabling public prosecution of cases that would have otherwise been left to private litigants.
3. Objectionability Criteria - This regulatory strategy is triggered when an odor is either complained of or deemed objectionable by a specified number or percentage of individuals. The only real difference between the objectionability criteria and a nuisance regulation is that, in the former, the criteria for establishing a violation are listed whereas, in the latter, they are not.
4. Ambient Sensory Approach - A Scentometer or other device is used to measure the "strength" of an odor by diluting odorous air with filtered odor-free air. The greater the dilution necessary to render an

TABLE 1. STATE AND SELECTED LOCAL ODOR CONTROL REGULATIONS

State/local agency	No regulation	Nuisance	Objectionability	Ambient sensory	Incineration or equivalent/ Performance Standard	Sensory emission std.	Odorant-specific	Policy statement	Applicable regulatory section	Changes since 1974	Relative agency priority
Alabama		✓					✓		(1.11 (5.4))		Low
Alaska		✓					✓		18 AA (50. 110, 50.060)		Low
Arizona	✓								-		A County matter
Arkansas		✓							82-1938 State Laws		Low
California		✓							Div 26, Pt4, §41700		
Bay Area*							✓				High
South Coast					✓						Moderate
Colorado				✓					Reg. #2		Moderate
Connecticut*			✓			✓	✓		19-508-23		Low
Delaware		✓							Reg. #XIX	✓	Important
D.C.		✓		✓					8-2-715		Low
Florida		✓					✓		17-2.04(4) &(6d)		Low
Georgia								✓	-		Low
Hawaii		✓							§5		
Idaho		✓			✓		✓		Sections K, O,Q		Low
Illinois		✓							Rules 102, 801, 802		Low
Indiana	✓								-		Low
Iowa*		✓			✓				§4.5(455B)	✓	Increasing
Kentucky*				✓			✓		401 KAR 3:020 Also 401 KAR 3:050§16; 401 KAR 3: 060§5		Moderate
Kansas	✓								-		Low
Louisiana	✓								-		Low
Maine	✓								-		Moderate
Maryland		✓			✓				§10.18.04.04 (A) & (F)		Low
Massachusetts		✓							Reg. #9		Moderate
Michigan		✓							R.336.46		Important
Minnesota*				✓	✓						Moderate
Mississippi		✓									Low
Missouri				✓					10 CSR 10-3.090	✓	Low
Montana		✓			✓		✓		§16-2.14(1)-S1480		Moderate
Nebraska	✓										Low
Nevada				✓							Low
New Hampshire		✓					✓				Low
New Mexico							✓				
New Jersey		✓									Important
New York		✓									
North Carolina					✓						Low
North Dakota*			✓	✓					CH.33-15-16	✓	Increasing
Ohio		✓									Low
Oklahoma	✓										Low
Oregon*					✓		✓				Moderate
Pennsylvania*					✓					✓	Low
Puerto Rico			✓			✓			PRTB		Increasing
Rhode Island			✓						Reg. No. 17	✓	Increasing
South Carolina	✓								-		Low
South Dakota	✓								-	✓	Low
Tennessee	✓								-		Low
Texas		✓									Moderate
Utah	✓								-		
Vermont			✓		✓						Moderate
Virginia		✓					✓			✓	Low
Washington							✓				Moderate
West Virginia			✓								Moderate
Wisconsin			✓								
Wyoming				✓	✓						Low
Wayne County*						✓					Moderate

*Selected for in-depth review in this report

odorant undetectable, the greater its "strength." Scentometer-based regulations are premised upon very limited experimental evidence, indicating that ambient odors above 7 "dilutions to threshold"* will probably cause complaints, while those above 31 can be described as serious nuisances if allowed to persist for even a short time.[3] This approach applies to all odors, regardless of their "objectionability" and is limited to ambient air (as opposed to stack) measurements.

5. Control Technology-Based Regulations - Several states approach odor control regulation by requiring specified odor sources to install and use "best practical controls." Such control requirements are typically phrased in terms of an incineration, or equivalent, standard and are not directly related to community odor levels.

6. Sensory-Based Source Emission Standards - Five jurisdictions (see Table 1) impose source emission standards for odors measured in terms of the odor "concentration" in the stack gas stream. With this approach, a stack gas sample is collected and applied to a random panel of individuals. These panel samplings are used to determine the "dilution to threshold" or D/T of the emission, which is phrased in terms of "odor units per cubic feet." In Connecticut, for example, odor source emissions are limited to 120 "odor units per cubic foot."[5] This means that, after diluting any sample of the emission stream to 120 times its volume by odor-free air, only

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*The term "dilution to threshold" refers to the amount of pure air which must be added to a known volume of odorous air in order to dilute the sample to the concentration at which it can just be detected.

50 percent of the panel members would detect the odor from the diluted sample. The presumption is that natural atmospheric dispersion mechanisms will reduce a stack emission at least 120 times to a concentration below the detection threshold by the time it becomes fully mixed with the ambient air at the receptor.

7. Odorant-Specific Emission or Ambient Standards - One of the most promising odor control strategies, in terms of its adaptability to the Clean Air Act, establishes odorant-specific emission and/or ambient standards. Several state and local agencies, (as well as EPA) for example, have established source emission rules governing total reduced sulfur (TRS) emissions from kraft pulp mills. Other agencies have adopted specific ambient air quality standards for hydrogen sulfide (H_2S). From a federal odor control standpoint, the promise of these strategies is that the Clean Air Act is more easily applied to the regulation of specifically identifiable substances than it is to controlling an amorphous perceptual concept such as "odor."

8. Policy Statements - Two states, Delaware[6] and Virginia[7], have regulations that are, in effect, statements of agency policy against air pollution that results in odor. These regulations are similar in many respects to nuisance regulations.

9. Combination of Ambient and Source Standards - A few agencies, including the Bay Area,[8] Illinois,[9] and Minnesota,[10] combine the ambient and emission standard approaches to odor control. Illinois, for example, employs an ambient scentometer regulation as well as an incineration requirement (for rendering plants) in its odor control regulations.

As indicated in Table 1, few State and local odor control regulations have undergone any significant revisions since 1974. The nuisance approach remains the most widely employed strategy, and virtually all regulatory programs continue to rely upon citizen complaints for enforcement purposes. Furthermore, odor control regulations are assigned a low priority by most air pollution control agencies since odors are perceived as nuisances (i.e., welfare effects) rather than as a health concern. In addition, the unprecedented impact of the state implementation plan revisions called for by the 1977 Clean Air Act amendments further minimizes state and local agency concern for new federal odor control regulations. The preparation, adoption and enforcement of these revised implementation plans will consume the large majority of available State and local air pollution control resources during the forseeable future.

The current thinking of most state air pollution control agencies is to focus their odor-related efforts on those sources, typically few in number, causing the majority of citizen complaints. In most states, a relatively limited number of source categories are responsible for the large majority of citizen complaints. The odor sources that are most frequently the cause of complaints include:

- Pulp mill/kraft mill/wood products
- Land fill/dump/open burning
- Fruit and vegetable processing
- Fisheries and fish processing facilities
- Petroleum and natural gas refining/asphalt production
- Rendering/meat packing/slaughter houses/tanneries
- Fertilizer plants

- Sewage/human waste
- Feedlots/stockyards
- Incinerators
- Coffee roasting/spices
- Commercial-restaurant/dry cleaning
- Paint/varnish/lacquer
- Coating applications (paint coating, baking and drying)
- Diesel (and other mobile source) exhausts

State and local enforcement actions against specific problem plants in these general categories have been a frequent occurrence in the past and are certain to continue in the future. This is particularly true for state and local agencies which view odor problems as a relatively high enforcement priority. The most active jurisdictions in this enforcement area include: The South Coast and Bay Area Districts in California; Delaware; Massachusetts; Michigan; Wayne County, Michigan; Minnesota; New Jersey; Rhode Island; Texas; and, Washington.

Several conclusions can be drawn from this regulation survey. The most striking one is that, while most jurisdictions experience many odor problems,* few rank them as one of their top agency priorities. Most officials believe that, while existing regulatory approaches need to be improved, they are generally adequate to solve major community odor problems. The combination of citizen/agency pressure and threatened legal action is

*Surveys reveal that as many as one half of all air pollution complaints relate to odor. This high proportion is undoubtedly due to the perceptual nature of the problem, however, and does not mean that odor pollution is the most serious air pollution problem. People know when they do not like a particular odor. They may not know when they are being harmed by more subtle forms of air pollution such as carbon monoxide (CO).

generally sufficient to encourage problem sources to undertake voluntary compliance and abatement programs. Indeed, the vast majority of odor problems are resolved extra-judicially. Only in relatively rare cases of strong community pressure and stiff industry resistance do these matters require an adjudicatory resolution. In those cases in which a court action is indicated, the regulatory procedures used by Texas have proven very effective.[11]

Another important conclusion is that most odor problems (measured in terms of citizen compliants) are attributable to a relatively few source categories. This conclusion is very significant in terms of regulatory strategy development since it makes it possible to devise narrowly focused control programs with relatively high cost-benefit ratios. Specifically, if odors could be controlled from pulp and kraft mills, rendering plants, sewage treatment plants, meat packing and processing operations, feedlots, painting operations and a few selected chemical processes, many of the nation's odor problems would be solved. While this statement has a simplistic ring, it does lead to a tentative conclusions that emission (as opposed to ambient level) controls may be a more effective regulatory strategy for odors.

Regulating odor presents many problems, regardless of the air pollution control strategy employed. Technical uncertainties are legion and varying perceptions of and social attitudes toward odor tend to undermine any national or uniform regulatory strategy. Clearly, from a regulatory standpoint, the most difficult problem, is the absence of meaningful data that relate emission rates or ambient odor levels to community annoyance. In the final analysis, it is the elimination of community annoyance that ought to form the policy basis of odor regulation. Without reliable annoyance threshold data for specifically identified odorants, it is very difficult to devise

odor-control regulatory strategies that are grounded on this fundamental base. Ambient standards tied to "detection" or "recognition" thresholds are generally inadequate because they do not necessarily relate to the annoyance property of the odorant within the context of the community setting in which the odor is normally experienced. This lack of a close relationship can lead to violations even though no nuisance condition exists.

The irony of the situation is that efforts to establish quantified acceptability or annoyance threshold levels for any particular odorant are fraught with subjective evaluations. Subjective reactions to odor differ between individuals and between communities. Indeed, this factor is a major reason for the view that nuisance law is an appropriate mechanism for addressing odor problems. Despite all of its substantive, procedural and evidentiary shortcomings, the nuisance approach is the only odor-regulation strategy now in use that is tied directly to the basic criterion of an unreasonable interference with public or private rights.* As in other areas of nuisance law, odor nuisance disputes are resolved on the basis of lay testimony concerning the reasonableness of the defendant's

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*A public nuisance is created when the defendant's conduct invades a right common to all members of the public, such as the right to enjoyment of a park. A private nuisance, on the other hand, involves an invasion of a private party's interest in the use and enjoyment of his land. Since the Clean Air Act does not explicitly preempt the field of odor regulation, the two types of nuisance action would remain valid avenues for seeking abatement of unpleasant odors, even if ambient standards were established under that Act and the defendant was in compliance with them.[12]

Under the most widely recognized view, an odor problem must cause substantial annoyance to qualify as a nuisance. Unusually sensitive individuals are at a distinct disadvantage since annoyance is judged on the basis of the ordinary person living in that locality. Technical legal defenses and burdensome evidentiary problems also detract from the usefulness of nuisance actions and in most cases courts will not issue prohibitory injunctions even if the plaintiff prevails on the merits of his claim.[12]

behavior. The level of private or public annoyance is balanced against the defendant's interests in continuing to operate. Numerically based odor control approaches (ambient and source) lack this important feature. This is their basic shortcoming.

4.0 EVALUATION OF STATE AND LOCAL ODOR REGULATIONS SIMILAR IN FORM TO THOSE THAT COULD BE PROMULGATED UNDER THE CLEAN AIR ACT.

4.1 General Considerations

In judging the effectiveness of any odor regulations, few established guidelines exist. Presumably, the ideal regulation will prevent, reduce or eliminate community annoyance at minimum cost without introducing any significant new risks. Since annoyance, cost and "risk" are seldom measured in the same units, a direct comparison among them is difficult, and a simple numerical goal for effectiveness is not possible. Furthermore, secondary benefits of odor regulation, such as a general reduction in the number and quantity of pollutants inhaled by the population at large, an increase of real estate values, or improvement of corporate image, are even more difficult to quantify in similar units. They nevertheless are potential real secondary benefits of odor reduction.

Since the objective of this section is to evaluate the effectiveness of those existing state and local odor control regulations amenable to promulgation under the Clean Air Act, it is necessary to analyze the types of regulations available under the Act. Section 4.2 describes the regulatory options available.

4.2 Available Clean Air Act Regulatory Strategies

According to the Clean Air Act, four basic regulatory mechanisms may be used for controlling emissions to the atmosphere:

(1) Ambient Air Quality Standards (Sec. 108-110).

(2) New Source Performance Standards (Emission Standards) (Sec. 111).

(3) National Emission Standards for Hazardous Air Pollutants (Sec. 112).

(4) Motor Vehicle Emission Standards (Sec. 202).

The first option involves the establishment and attainment of national ambient air quality standards. Under this approach, EPA promulgates specific numerical ambient standards for specified (criteria) pollutants designed to protect public health (primary ambient standards) and public welfare (secondary standards). The Act delegates to the States the primary responsibility for attaining and maintaining these standards through the adoption and enforcement of State implementation plans (SIPs). For any given criteria pollutant, the SIP must set forth emission limitations and other control measures necessary to attain and maintain compliance with the ambient standards within the time established by the Act. The plans must also contain well defined procedures for preventing significant air quality deterioration resulting from major new emission sources in areas already cleaner than the standards.

The second available approach is through the promulgation of industry-specific new source performance standards.[39] Section 111 of the Act gives EPA the authority to establish standards of performance applicable to specific pollutants from new and modified* stationary sources. This provision recognizes that it is more practical to build pollution control into a new facility than to retrofit controls into an existing operation. New source performance standards require emission reductions that reflect that level of control achievable through application of:

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*A "modified" source is one that undergoes a physical or operational change which causes new or increased air pollution. A "new" source is one which commences construction after NSPS regulations applicable to that source category are proposed by EPA.

> "...the best technological system of continuous emission reduction which (taking into consideration the cost of achieving such emission reduction, any non-air quality health and environmental impact and energy requirements) the Administrator determines has been adequately demonstrated."

Before promulgating new source performance standards, EPA conducts tests of prototype and full-scale control systems, surveys pertinent literature, and documents manufacturer guarantees. These efforts are required in order to identify appropriate control systems which have been adequately demonstrated and which will be available in time to allow compliance by the affected industry.

Once the standard is set, the owner or operator need not use the control system identified by EPA, but the standard must be achieved. Normally, installation and operation of a particular control system is not enough; compliance is based on actual emissions. Only where it is not feasible for EPA to establish a numerical emission standard (e.g., petroleum storage vessels), may the agency establish NSPS requiring specified design or control techniques. In all other cases, the standard must reflect a quantified level or percentage reduction of emissions from the control system.

In addition to requiring performance standards for new and modified stationary sources, Section 111 also requires the states to adopt performance standards for "designated pollutants" from certain existing sources under Section 111(d). A "designated" pollutant is one which is subject to an NSPS but which has not been listed as "hazardous" under Section 112 of the Act or which is not listed as a Criteria Pollutant under Section 108.

If EPA promulgates an NSPS for a designated pollutant from new sources of a specific source category, an emission standard must be established by the

states governing emissions of that designated pollutant from all existing sources within the category. Fluorides from phosphate fertilizer and aluminum plants, sulfuric acid mist from acid plants, and total reduced sulfur compounds from pulp mills have been regulated under Section 111(d). Any standards applicable to odors under the NSPS program would qualify as "designated pollutant standards," thereby triggering existing source controls under Section 111(d).

Section 112 of the Clean Air Act authorizes EPA to promulgate national emission standards for new and existing sources of "hazardous air pollutants". The Act defines these pollutants as those capable of causing or contributing to an increase in mortality or serious illness. To date, EPA has used Section 112 sparingly, reserving it for the regulation of extremely dangerous pollutants such as mercury, asbestos, beryllium and vinyl chloride. Given the present uncertainty regarding the public health effects of odors, it seems quite doubtful that EPA could promulgate a defensible hazardous emission standard for the control of specific odorant or for odors generally. The potential advantages and disadvantages of this regulatory strategy will, therefore, not be analyzed further in this report.

In addition to the basic NSPS authority under Section 111, EPA is also empowered by Section 202 of the Clean Air Act to establish standards applicable to emission of any air pollutant from new motor vehicles or new motor vehicle engines. Conceptually these standards may be thought of as a special type of new source performance standard. They are intended to apply to vehicles or engines throughout their useful lives and to take effect after such period as the Administrator finds necessary to permit the

development of the requisite technology, giving appropriate consideration to the costs of compliance. The basic process for establishment of standards under Section 202 applicable to odors originating from motor vehicles would be comparable to that described above with respect to Section 111.*

4.3 Comparison of Ambient and Emission-Based Regulatory Approaches

The national Air Pollution Control Association (APCA) has a standing committee (the APCA TT4 Odor Committee), charged with review of basic odor control technology and regulation. Many of its members have contributed technical articles on odor regulations in recent years. After critically reviewing odor control regulations, the APCA Odor Committee was equally divided on the issue of selecting stack ("emission") as opposed to ambient type standards for odors. The following excerpt from the Committee's 1978 Report highlights the essence of the debate.[2]

> "Both approaches have strengths and weaknesses. The stack emission approach has obvious advantages over an ambient odor type regulation regarding the relative ease and lower cost of sampling and analyzing odors. Also, the emission source of objectionable odors is more readily determined by using stack measurements. However, the stack emission type approach requires an additional technical step - the correlation of stack emission with ambient odor concentration, either by obtaining empirical data or by use of atmospheric dispersion models, in order to be able to judge whether or not the resulting ambient odor concentration is acceptable to the community.
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> "On the other hand, if odor annoyance threshold data are available, an ambient odor limit can be related to a particular zoned area and specified to avoid an odor annoyance being experienced by the population that lives or works in a particular zoned area. Further, it should be recognized that odors do not discharge only from stacks or well-defined enclosures but could originate from fugitive type emissions (i.e. anaerobic lagoons). As a result, it may be necessary in certain areas to have a combination of stack emission and ambient odor regulations available to control all significant sources of odor."

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* For three of the pollutants covered by national ambient air quality standards (HC, CO, and NO_x), the vehicle emissions standards established under Section 202 must correspond to reductions specified in the Clean Air Act. However, this does not apply to odorous substances as such.

4.4 Local Programs Studied

Two local and eight State odor control programs were selected for careful analysis based upon 1978 regulatory programs:

1. The Bay Area Air Quality Management District in California
2. The Wayne County Health Department in Michigan
3. Connecticut
4. Iowa
5. Kentucky
6. Minnesota
7. North Dakota
8. Oregon
9. Pennsylvania
10. Rhode Island

All of these jurisdictions have odor control programs containing elements similar to those which could be promulgated by EPA. Each has also had relatively extensive experience in dealing with odor problems.

Conceptually, the regulations of these 10 jurisdictions can be divided into five categories: two "ambient" apprcaches, and, three "emission based" approaches. Table 2 presents this categorization scheme.

4.5 Criteria for Determining Regulatory Effectiveness

Although it is difficult to judge the overall effectiveness of any environmental regulation since many social, ecoromic and administrative factors are involved, several criteria of an "effective odor regulation" can be given:

1. It offers an effective mechanism for resolving community odor nuisances in a timely fashion.

2. It resolves problems in an equitable manner.
3. It requires only a reasonable commitment of private and public financial and manpower resources in light of the nature and magnitude of the problem.
4. It is responsive to community attitudes and sensibilities.*
5. It is enforceable.

Unfortunately, the effectiveness of odor regulations have not been empirically analyzed. Much insight can be gained, however, from reviewing available literature and through conversations with knowledgeable individuals in the governmental, industrial and academic sectors. The following sections apply the above-mentioned effectiveness criteria to the regulatory strategies employed by the agencies surveyed. Many of these agencies employ a combination of approaches, and when this is the case, those agencies' regulations will be analyzed in more than one section of the report. For purposes of analysis, the following categorization will be followed:

Ambient Approaches

1. Objectionability at property line
2. Scentometer
3. Odorant-Specific Ambient Standards

Emission-based Approaches

1. Odor level standards
2. Incineration or equivalent standards
3. Odorant-specific performance standards

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*This is a more relevant consideration for odor regulation than for other environmental controls because of the subjective nature of the problem.

TABLE 2. STATE ODOR CONTROL STRATEGIES
AMENABLE TO THE CLEAN AIR ACT

Approach	Jurisdiction	Regulation	Operative Regulatory Language
Ambient (Non-odorant specific)	Bay Area	§15105	No person shall cause, let, permit, suffer, or allow the emission of any odorous substances which causes the ambient air at or beyond said person's property line to be odorous and to remain odorous subsequent to its dilution with 4 parts of odor-free air. (Dynamic olfactometer/triggered by specified frequency of complaints.)
	Connecticut	§19-508-23(a)(1)	Objectionability to staff investigator, considering nature, concentration, duration and location (beyond property line).
	Iowa	§400-4.5 (455B)	Violation occurs if odor is of such frequency, duration, quality and intensity as to harm public health or welfare or cause a nuisance.
	Kentucky	401 KPR 3:020 §4(10)	Ambient standard not to exceed 7 dilutions (scentometer)
	Minnesota	APC 9§(c)(4)	(4) No odor source shall emit air contaminants into the ambient air which cause odor outside the alleged polluter's property line in excess of the following limitations: (aa) One odor unit in areas zoned residential, recreational, institutional, retail sales, hotel or educational. (bb) Two odor units in areas zoned light industrial. (cc) Four odor units in areas zoned other than in subsections (aa) and (bb) above.
	North Dakota	§33-15-16-02	Limit of two odor concentration units outside property line (scentometer of ASTM).
	Rhode Island	Regulation No. 17	Objectionability to staff investigator, considering nature, concentration, location, duration, and source (beyond property line).
Ambient (Odorant-specific)	Connecticut	§19-503-23(a)(3)	Ambient threshold values established for 53 odorants.

TABLE 2 (Cont.)

APPROACH	JURISDICTION	REGULATION	OPERATIVE REGULATORY LANGUAGE
Emission-based (Non-odorant specific)	Wayne County, Mich.	Informal Agency Guidelines (Judicially upheld)	150 odor units/cubic foot - specified syringe dilution technique
	Connecticut	§19-508-23(a)(2)	120 odor units/cubic foot - Mills ASTM adaption
	Minnesota	APC 9§(c)(1-3)	(c) Odor Emission Limits. Violation of APC 9 shall be any discharge of air contaminants in excess of the following odor emission limits: (1) Odor sources emitting from well-defined stacks 50 feet or more above grad elevation and with adequate dispersion characteristics as determined by the Agency shall not emit odors in greater than 150 odor concentration units. (2) Odor sources of less than 50 feet elevation above grade or otherwise failing to create good dispersion conditions as determined by the Agency shall not emit more than 25 odor concentration units. (3) No odor source shall have an odor emission rate in excess of 1,000,000 odor concentration units per minute.
	Bay Area	§15103	Variable dilution rate depending upon elevation of emission point (triggered by specified frequency of complaints).
Emission-based (Performance standards)	Iowa	§20.3(1)(4)	Standards for anerobic lagoons.
	Oregon	§§25-055, 25-150 and 25-350	Standards for reduction of animal matter, kraft pulp mills and sulfate pulp mills.
	Pennsylvania	§123.31(a)	Incineration or equivalent standard for 15 listed source categories (and all sources of H_2S or mercaptans).
	Bay Area	§15106	TRS emissions from kraft pulp mills.
Emission-based (Odorant-specific)	Bay Area (Calif.)	§15104	Specific emission limitations established for dimethylsulfide, ammonia, mercaptans, phenolic compounds and trimethylamine. Varies with characteristics of emission source and excludes kraft pulp mills.
	Pennsylvania	§123.31(a)	Incineration or equivalent standard for all emitters of H_2S or mercaptans.

Combination Approaches

1. Minnesota

2. Bay Area

4.6 Ambient Approaches

Modern ambient odor regulations are typically phrased either in terms of the objectionability or detectability of odors at the plant boundary. Many agencies use ambient approaches in tandem with emission limitations, nuisance laws, or both in order to maximize enforcement flexibility.

4.6.1 The Objectionability Approach

In Connecticut,[5] Iowa[11] and Rhode Island,[12] an agency inspector checks, without instrumentation, such factors as the nature, concentration, duration and location of the alleged emission, relying only on his own perception of the alleged objectionable emissions. In almost all cases, inspectors in these states respond only on the basis of odor compliants directed at a particular source. The agency does not seek out odor violations since community odor complaints are believed to be the best measure of whether or not a problem exists.

An obvious advantage of this approach is that it is generally easy and inexpensive to administer, especially where a single source is clearly responsible for the problem. In addition, it is responsive to community sensibilities in that it is triggered by complaints. In the three states surveyed, it was indicated that this method is a reasonably effective one for solving community odor problems. Furthermore, the objectionability approach avoids many of the technical impediments inherent in more sophisticated methodologies. The subjective response of the inspector determines whether or not there is a violation irrespective of what a quantitative chemical or sensory analysis might show.

The disadvantages of the objectionability approach flow directly from those features that make it desirable. The high degree of subjectivity in the enforcement process makes possible problems of inequitable application of the law and an inability of source owners to effectively plan for compliance. In many ways, the objectionability approach is no different from the traditional public nuisance approach in that violations are established primarily on the basis of testimony from affected residents and from the agency inspector as to the objectionable nature of the source's emissions. While this approach enables official investigation and public prosecution of cases that would otherwise be left to the law of private nuisance, it does little more than codify traditional nuisance standards.

The State of Connecticut has had significant experience with the objectionability regulatory approach. Officials within the Connecticut Department of Environmental Protection (DEP) believe that the approach has worked reasonably well for controlling industrial odor problems although industry representatives are justifiably dissatisfied with the inherent subjectivity it requires. Difficulties arise, however, where odor complaints are raised in connection with existing or proposed non-industrial sources such as neighborhood restaurants or automotive repair shops. In these situations, poor local zoning laws are frequently the true basis of the problem. State air pollution control agencies are justifiably loath to become involved in minor local land use disputes.

Despite this limitation, the DEP's use of the objectionability approach is significant in that it has the legal authority to impose both ambient and emission-based odor standards. Connecticut's odor regulation prohibits the discharge of "objectionable" odors beyond the source property line. An odor is deemed "objectionable" when:

1. A staff member of the Department of Environmental Protection determines, following personal observation, that the odor is objectionable, taking into account its nature, concentration, location, and duration; or,
2. Samples from the source are taken and found to rate over 120 odor units per cubic foot as determined by Mills' adaptation of ASTM D-1391-57;[15] or,
3. If the odor is caused in whole or in part by a listed substance and when the specified concentration is exceeded for any period of time as demonstrated by analysis made in accordance with methods approved by qualified professional chemists.*

Connecticut DEP has found the modified ASTM and the odorant-specific ambient standard technique to be less effective than the objectionable-odor approach. The agency has been able to resolve most of its odor complaints without resorting to the use of odor panels or chemical analyses of property line odorant concentrations. One of the principal reasons for the agency's reliance on the subjective objectionability approach is that it provides a more reliable (albeit subjective) indicator of a true community odor nuisance. As noted earlier, the modified ASTM and other detectability-based regulatory standards may or may not protect against community annoyance.

4.6.2 Ambient Sensory Regulations

Several State and local agencies specify the use of a Scentometer as the recommended method for determining the allowable ambient level of odor pollution. Of the States surveyed, the approach is used in two: Kentucky[16] and North Dakota.[17]

*Connecticut's listed threshold values have proved to be essentially unworkable and unrealistic. Adequate measurement techniques have not been developed and there is no data that sufficiently confirms the reasonableness of the levels in terms of odor response.

The Scentometer consists of a small rectangular chamber that contains two sniffing tubes on top for insertion into the nostrils. Normal breathing draws the odorous air from the surrounding environment through the bottom panel and also through the two side panels, which contain activated carbon to provide odor-free air for dilution. The bottom panel is provided with several calibrated holes of varying diameter to vary the dilution ratio. These holes, which correspond to specific ratios of dilution to threshold (D/T), are designated in some odor regulations as a Scentometer reading number having a specific numerical odor strength. The device is limited to diluting the odor stimulus only to specified levels (e.g., 2, 7, 15, 31, 127 and 249 dilutions), with no adequate provision for achieving a graduated degree of dilution in between. The States of Kentucky and North Dakota specify allowable Scentometer readings of 7 and 2, respectively.

Although the Scentometer represents an inexpensive and administratively simple odor regulatory approach, it has certain basic disadvantages, which affect its trustworthiness as an enforcement tool. First, it normally is used by only one individual. Odor sensory responses by different people are highly subjective and can vary widely. (Odor sensory evaluation conducted with nine-member panels at IIT Research Institute and at TRC (The Research Corporation of New England) indicated that a tenfold variation in sensitivity normally exists among panel members. Occasionally, the difference was as high as a hundredfold). In addition, an individual's response to odor may vary from day to day. The Scentometer method does not provide for the selection of an odor sensory panel to average out high and low individual responses. These factors cause courts and administrative officials grave concerns about the ability to sustain enforcement actions where millions of dollars in control costs may be at stake.

Second, the construction of the instrument does not provide a reliable means for an individual to isolate his or her nose from the odorous environment being monitored. Depending upon the individual's pattern of breathing and ability to seal off the nasal passages with two sniffing ports, it seems reasonable to expect that any odor in the ambient air could bypass the instrument and be sensed directly by the nose, thus resulting in a false positive response. Since the individual is surrounded by an odorous environment, it may not be possible to isolate the contribution of of the suspected sources.

Third, as mentioned before, certain agencies have specified dilution-to-threshold levels in their regulations that were intermediate between 2 and 7 D/T or between 7 and 31 D/T. On the basis of various discussions with State and local agencies, the range of 2 to 7 D/T is particularly critical, and an odor sensory method is needed that accurately determines the odor dilution ratio within this range.[2] The Scentometer cannot fill this need.

Finally, the Scentometer is not necessarily related to community annoyance. While investigators have attempted to correlate Scentometer readings to community odor nuisance, the fact remains that the Scentometer measures odor detection, not odor annoyance. This basic dilemma, in concert with the above-mentioned limitations, led the APCA Odor Committee to conclude that the Scentometer is not a satisfactory instrument for measuring ambient odors for regulatory purposes.[2] This conclusion is shared by agency officials in both Kentucky and North Dakota.

4.6.3 Odorant-Specific Ambient Standards

With the exception of ambient H_2S standards, few state or major local agencies use odorant-specific ambient standards to regulate odor pollution. Ideally, an odor regulation would be odorant-specific rather than depend

on a general detectable odor standard. Unfortunately, not enough is known about the olfactory parameters of specific chemical substances. Although detection thresholds have been established for most of the more ubiquitous odorants such as H_2S and mercaptans, the reliability of these threshold values are a subject of controversy. Furthermore, generally accepted annoyance threshold values simply do not exist.

One agency which has made a significant effort to specify and regulate the ambient concentration of designated odorants is Connecticut. Although Connecticut has identified ambient odor threshold limits for 58 chemical substances, it does not rely on these threshold values in the enforcement of its odor regulation since the agency has little confidence in the correlation of these concentrations to community annoyance or nuisance conditions.* In short, the response of the human nose to chemical stimuli is simply not subject to precise quantification, especially in real-world ambient settings.

These Connecticut standards are based on a study by Arthur D. Little Inc., which determined odor threshold values for 53 commercial chemicals.[18] These odor threshold concentrations were determined with a panel of four trained professional people. The odor test room was designed to provide a minimum of background odors.

It is significant that the Arthur D. Little report on this specific work states that "the recognition odor thresholds reported in this study, determined as they were by trained panelists under ideal conditions, are not presented as indicative of concentration levels at which these compounds might constitute an odor problem in the ambient malodorous atmosphere. No attempt has been made to assess the degree of objectionability of the odorant chemicals, and the determina-

*Development of reliable sample collection procedures also presents a problem

tion of "odoriferous" concentrations in ambient air, for any given chemical and background odor moiety, would require field testing."[18]

4.7 Emission-based Approaches

Odor control strategies that focus on emissions avoid many of the problems inherent in ambient approaches. Most importantly, emission oriented controls eliminate the problem of having to quantify the precise ambient impact of the emitting source. Although the emission limits should be related to ambient impact in a general way*, compliance is determined on the basis of a quantitative analysis of the stack gas, not the ambient air into which the gaseous odorants diffuse.

This is not to say, however, that emission based controls are problem-free, since emission controls suffer from many of the same difficulties as ambient techniques. The most common emission based approach is the establishment of source and odorant-specific incineration or performance standards. For example, TRS standards for kraft pulp mills and incineration requirements for rendering plants have been promulgated by several air pollution control agencies. While these regulations are reasonably objective and specific, they only address a limited part of the total odor problem and do not necessarily insure the avoidance or resolution of community odor problems.

Another emission based alternative is the specification of the maximum odor dilution ratio of the stack emission. Under this approach, a source

*In setting odor emissions limits, anticipated ambient impacts associated with selected emission levels should be a central consideration. As noted earlier, however, the data on which to base such determinations is quite sparse.

may emit only a specified number of "odor units" per cubic foot of total emissions. An "odor unit" is defined as the number of cubic feet of odor-free air needed to dilute one cubic foot of the odorous emission to the point where the diluted sample cannot be detected by a specified percentage (typically 50 percent) of an odor sensory test panel. Connecticut specifies an odor emission limit of 120 odor units per cubic foot based upon the ASTM method as modified by Mills. Minnesota uses a similar approach employing a different modification of the ASTM method[20] but makes a distinction regarding stack height in specifying source emission odor limits.

4.7.1 The Odor Level Standards Approach

Several agencies, including Wayne County, Michigan; Connecticut; and, Minnesota specify a modified ASTM syringe dilution technique for assessing odorous stack emissions.

The basic method consists of taking a sample of the exhaust gas in a 100 cc. cylinder or 250 cc. glass tube. The gas sample is then evaluated under controlled conditions by a panel of trained individuals in an essentially odor-free environment. An odor panel of six to eight persons is normally selected by a prescribed odor sensory test to ensure the selection of people having average olfactory perception.

Individual odor panelists receive a series of pre-determined odor dilutions in 100 cc. syringes. Each panel member must smell momentarily a rapidly expelled pulse of odorous air from the 100 cc. syringe whose tip is directed toward the nostrils. The panelist indicates either a negative or positive response to the odor being detected and the panel's responses are correlated with the various odor dilution levels. The median odor threshold level is defined as that dilution level where 50 percent of the panel does not detect the diluted odor stimulus.

The advantages and disadvantages of the ASTM approach have been widely discussed in the literature. William H. Prokop of the National Renderer's Association summarizes the issues and makes specific recommendations in a paper entitled Status of Regulations for Source Emission and Ambient Odors:[21]

> "Although Friedrich and Benforado reported reliable results with the ASTM syringe method, it was emphasized that training of the odor sensory panel is important and following consistent procedures is necessary. The basic method lacks a defined procedure for odor stimulus presentation since the various odor dilutions are to be randomly presented to the panel by mixing the order of strong and weak odor stimuli. Sometimes, a blank or odor-free sample is substituted to check the panel's reaction. This has tended to produce confusing results and as a consequence, no satisfactory provision is available to check the reliability of positive-negative responses of the panel.
>
> "These basic shortcomings of the ASTM method were recognized by industry and an ASTM Task Group was organized to review the method. A position paper dated March 12, 1973 was prepared by this committee that critically evaluated the syringe dilution technique. The Committee basically concluded that an ascending order of odor concentration should be used in the presentation of odor stimuli to the panel and that at each level two syringes be submitted to the panelist. One syringe contains the odor stimulus and the other is a blank containing odor-free air. A forced choice answer is required; odor in the first or odor in the second.
>
> "Dynamic sensory methods are considered to be more reliable than static methods and have been developed by a number of investigators. Static odor sensory methods do not have any satisfactory provision to check the reliability of positive-negative responses of the panel. An approach is, therefore, desired where the diluted odor sample is presented to the panel for discrimination from samples of non-odorous air and results can be related to statistically significant confidence levels."

At the present time, only the Bay Area Air Quality Management District uses the dynamic approach.[8] It is suggested that this approach is superior to current static techniques thereby enhancing the effectiveness and enforceability of the regulation.

Agency experience with the static ASTM approach (and its modifications) has been mixed. As indicated earlier, Connecticut has decided to ignore its static ASTM provision, relying instead on the more subjective "objectionability" criteria. Air pollution officials in Wayne County, Michigan, on the other hand, believe that they have had good success in the application of the static modified ASTM approach. The validity of the method has been supported by a legal decision of the Michigan Court of Appeals.[22] The agency attributes its success to the significant experience it has had with this method. This experience has allowed the agency to develop some useful variations of the ASTM approach, which enhance its reliability. The agency believes that its across-the-board odor concentration unit approach has excellent general applicability for urban odor sources.

4.7.2 Incineration Standards

Numerous State and local regulatory authorities, including the Commonwealth of Pennsylvania, use an incineration or equivalent standard for regulating odorous emissions from designated source categories. Pennsylvania's standard is not atypical, and reads as follows:[23]

> "(a) (1) No person shall cause, suffer or permit, at any time, any emissions from the following processes unless the emissions have been incinerated at a minimum of 1200 degrees F. for at least 0.3 seconds prior to their emission into the outdoor atmosphere: chip dryers, animal blood dryers, asphalt oxidation, asphalt roofing manufacture, brake shoe debonding operations, core ovens, rendering cookers, varnish cookers, paint-baking ovens, meat smokehouses other than those in single family farms, plastic curing ovens, fabric-backing and fabric-coating baking ovens, ovens for curing of binders in mineral wood production, meat processing other than in single family farms, tear gas manufacture and sources of hydrogen sulfide or mercaptans. (2) Techniques other than incineration may be used to comply with the provisions of clause (1) of this subsection if it is shown to the satisfaction of the Department that such techniques are equivalent to or exceed the required incineration in terms of control of the odor emissions.

"(b) No person shall cause, suffer, or permit the emission into the outdoor atmosphere of any malodorous air contaminants from any source whatsoever, including those in compliance with the provisions of subsection (a) of this section, in such a manner that the malodors are detectable beyond the property of the person.

"(c) The prohibition in subsection (b) of this section shall not apply to odor emission arising from the production of agricultural commodities in their unmanufactured state on the premises of the farm operation." (Emphasis added).

The most important objection to the incineration standard approach is that it requires control regardless of the fact that a community odor problem may not be caused or threatened by the source. Critics point out that it is wasteful to impose substantial hardware, maintenance and energy costs on odor sources unless necessary to prevent an odor nuisance. Such an approach is contrary to the recommendation of the APCA Odor Committee that an existing or potential odor nuisance should be established before controls are required.[2]

The Commonwealth of Pennsylvania has recognized this flaw in the regulation and has corrected it administratively by requiring the establishment of a community odor problem before incineration will be required*. With this administrative adaptation, the Pennsylvania regulation has worked quite well according to agency officials. By reserving sanctions for sources truly causing community nuisances, the regulation can be narrowly focused.

Another advantage of the Pennsylvania approach is that it combines odorant and source-specificity by enumerating 15 source categories as well as all sources of hydrogen sulfide and mercaptans-two of the most wide-

spread odorants in Pennsylvania. This feature allows industry to be put on notice that they may be subject to controls unless they prevent an odor nuisance from arising. At the same time, however, by prohibiting the discharge of any malodors beyond the source property line, the regulation prevents its own specificity from creating regulatory gaps regardless of compliance with the source and odorant-specific incineration standard of the regulation.

An additional advantage of the Pennsylvania approach is that it allows alternatives to incineration, which are equally effective. While incineration is the best-developed odor control for many sources, it is poor policy to preclude new or innovative technological approaches. This flexibility of allowing source owners to propose less costly means of equivalent odor control fosters technological development and should be incorporated into all incineration standards.

Finally, the incineration approach avoids the complex subjective uncertainties inherent in the ASTM and Scentometer approaches, although determining whether another control method is equivalent to incineration may introduce problems of subjectivity. Compliance assessment is relatively routine, thereby eliminating the enforcement problems that plague the subjective regulatory strategies.

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*This is a case-by-case determination based upon the nature of the problem and the number of valid citizen complaints.

4.7.3 Source-specific Performance Standards

For many years, performance standards for specific odorants from designated source categories have been used to control odorous emissions. Indeed, EPA has promulgated a federal New Source Performance Standard for pulp mill TRS emissions.[23] States are, therefore, obligated under Section 111(d) of the Clean Air Act to regulate TRS emissions from existing mills.

The greatest advantage of the performance standard approach is that it allows the agency to focus its resources on problem sources without getting bogged down in efforts to quantify stack or ambient "odors" through subjective sensory techniques. In areas where a few well-defined sources are responsible for the bulk of the odor complaints, this approach may well be the best one from both an economic and an administrative standpoint.

In Iowa, for example, anaerobic lagoons were perceived as one of the State's most serious odor problems. In response to increasing numbers of public complaints, Iowa enacted its first odor control rules in May 1977.[13] The rules established a construction permit program for new anaerobic lagoons and a nuisance-type odor standard for other odor sources. The construction permit provisions require that new anaerobic lagoons submit to a preconstruction review by the Iowa Dept. of Environmental Quality (DEQ). The review will assess the lagoon's odor production potential and water pollution potential. Implementation of the new rules is still under consideration, pending the outcome of public hearings designed to resolve differences between the rules developed by the DEQ and a new statute passed by the Iowa General Assembly.

While the performance standard approach works well in areas with relatively few odor sources, sole reliance on source-specific performance

standards in heavily urbanized or industrialized areas is not practicable. The variety of odor sources and odor complaints prevents the agency from establishing source performance standards for all potential sources.

In summary, source performance standards for specific odor sources can be a very effective odor-control technique where only a few sources or sources categories are responsible for most of the odor problem. Where this is not the case, as in much of the urbanized Eastern United States, performance standards for major odor sources must be supplemented with more general and more flexible alternatives.

4.8 Combined Ambient-Stack Approaches

Whether an emission or ambient approach is more effective frequently depends upon the nature of the odorant and the characteristics of the source. In the case of well-defined sources of odorants for which annoyance threshold data are available, ambient standards may be appropriate.* In other cases, ambient standards are impractical to administer, and emission standards must be employed.

4.8.1 Minnesota

The State of Minnesota has an odor regulation employing a combination of odor emission limitation and ambient standards.[10] With respect to odor emission limitations, a three-pronged approach is used. Under Minnesota regulation APC 9, the following limitations apply:

> Odor Emission Limits* Violation of APC 9 shall be any discharge of air contaminants in excess of the following odor emission limits:

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* At present, adequate annoyance threshold data do not exist for any major odorant.

(1) Odor sources emitting from well-defined stacks 50 feet or more above grade elevation and with adequate dispersion characteristics as determined by the Agency shall not emit odors in greater than 150 odor concentration units.

(2) Odor sources of less than 50 feet elevation above grade or otherwise failing to create good dispersion conditions as determined by the Agency shall not emit more than 25 odor concentration units.

(3) No odor source shall have an odor emission rate in excess of 1,000,000 odor concentration units (O.C.U.) per minute.

Although the odor emission limitations in APC 9 may be restrictive, the effectiveness of this three-pronged approach lies in its recognition of the significance of odor dispersion and total mass loading.

The effectiveness of the one million O.C.U./minute standard is more controversial. This limit is obtained by multiplying the volumetric emission rate in cubic feet per minute by the odor dilution ratio measured at the emission source[24] and expressed in odor units per cubic foot. The APCA TT4 Odor Committee made the following comments on this approach:[2]

The Committee was equally divided regarding their approval of or opposition to a total odor emission rate being applied for regulatory purposes. Those in favor considered this concept to be useful since another dimension other than odor concentration is available for evaluating an odor nuisance. In particular, it provides the means for totalizing a multiple number of odor emissions from a single source.

Those opposed to this concept recognize it has a certain validity when applied to small volume emissions. However, they question this concept when applied to large volume emission, for example, from plant ventilating air scrubbers. Based on the previously cited total odor emission limit of one million odor units per minute, a 100,000 cfm scrubber would be allowed a stack emission odor concentration of only

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*Minnesota which utilizes a modified ASTM method for determining compliance with its odor emission limitations, also has an incineration standard for animal matter processing facilities (APC 10).

10 odor units. This clearly is unrealistic and it is doubtful whether the specified syringe dilution technique is sufficiently sensitive at this low odor level to establish compliance reliably. The basic objective for an odor regulation should be to limit the ambient odor concentration at ground level, C_{max} rather than the total odor emission rate, Q. where both terms relate to atmospheric dispersion models.

It appears that the concept of total odor emission rate could be useful as a guideline for evaluating an odor nuisance but it should be applied judiciously for regulatory purposes*.

Minnesota's ambient regulatory approach for odors is somewhat novel but it results in problems of enforcement. It provides:

(4) No odor source shall emit air contaminants into the ambient air which cause odor outside the alleged polluter's property line in excess of the following limitations:

(aa) One odor unit in areas zoned residential, recreational, institutional, retail sales, hotel or educational.
(bb) Two odor units in areas zoned light industrial.
(cc) Four odor units in areas zoned other than in subsections (aa) and (bb).

The effort to distinguish between area types is sound policy in the abstract. However, this approach results in some very difficult technical and administrative problems in enforcement. Attempts to estimate the ambient odor impact of a source on "zoned" areas proved to be unworkable and is no longer being enforced in Minnesota. Techniques for estimating the impact of individual sources on ambient odor levels may become essential if odors were ever to be regulated as a criteria pollutant under the Clean Air Act. In particular, it would be important to be able to estimate

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* The Committee noted with interest that Minnesota relies basically upon its stack emission limits, expressed in odor units per cubic foot, for enforcement of its odor regulations.

ambient odor impacts to determine compliance with the prevention of significant deterioration of "clean" areas.

4.8.2 The Bay Area Air Quality Management District

Probably, the most clearly drafted and well conceived odor regulation in effect today is that of the Bay Area Air Quality Management District serving the San Francisco - Oakland metropolitan area. Division 15 of the Bay Area regulations establishes a comprehensive scheme for regulating ambient and stack odors. The regulation blends specificity of scope and broad general standards in a way that maximizes its effectiveness.

The regulation begins by defining its scope. Specifically, occupational odors, as governed by the California Department of Industrial Relations, are not subject to Division 15. The regulation also provides express exemptions for the following sources and operations:

(a) Single family dwellings

(b) Restaurants and other establishments for the purpose of preparing food for human consumption, which employ less than 5 persons

(c) Materials odorized for safety purposes

(d) Materials possessing strong odors whose use is necessitated for reasons of public health and welfare and where no suitable substitute is available and where best modern practices are employed.

(e) Agricultural operations as described in the California Health and Safety Code, Section 41705.

The regulation also specifies that compliance does not exempt anyone from compliance with the State's nuisance law. That regulation is triggered upon the receipt of five citizen complaints and provides an effective tool for resolving minor odor problems on an informal basis.[26]

The emission limitations of Division 15 are not applied in the absence of evidence indicating that a potential odor nuisance exists. Specifically, § 15100 provides:

> "The limitations prescribed in § 15103, § 15104, § 15105 and in § 15106.1 through 15106.6 shall be, and shall remain, applicable to a person responsible for an emission regulated by any of these sections after the Air Pollution Control Officer has recieved odor complaints from ten or more complainants, within a 90-day period, alleging that said person is responsible for odors perceived by the complainants at or beyond the property line of said person, and deemed to be objectionable by them in the normal course of their work, travel, or residence."

Once triggered by the required number of complaints, Division 15 imposes four substantive requirements:

1. § 15103 - A general odor emission limitation based on the dilution ratio concept and applicable to all odorous substances emitted by any source*. Specific recognition of diffusion characteristics is provided by allowing odor intensity to increase in direct proportion to stack discharge height as set forth on the following page:

2. § 15106 - Limitations for Total Reduced Sulfur at Kraft Pulp Mills. (Also, Division 17 of the Bay Area regulations establishes an incineration standard for rendering plants.)

3. § 15105 - An off-property ambient limitation of four dilutions to threshold for all odorant substances. Compliance is also determined through the dynamic olfactory method.

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* Compliance is determined through a dynamic olfactory approach.

Elevation of emission point above grade (feet)	Dilution rate (volumes of odor-free air per volume of source sample)
Less than 30	1,000
30 to 60	3,000
60 to 100	9,000
100 to 180	30,000
Greater than 180	50,000

2. §15104 Emission limitations for five particularly troublesome odorants. Again, source emission characteristics are factored into the standards as shown below:*

MAXIMUM ALLOWABLE EMISSION CONCENTRATION IN PPM

Compound or family of compounds	Type A emission point	Type B emission point
Dimethylsulfide $(CH_3)_2S$	0.1	0.05
Ammonia NH_3	5000	2500
Mercaptans calculated as methylmercaptan CH_3SH	0.2	0.1
Phenolic compounds calculated as phenol C_6H_5OH	5.0	2.5
Trimethylamine $(CH_3)_3N$	0.02	0.01

Specific analysis procedures are established for each odorant.

*Type A emission points have better dispersion characteristics than do Type B emission points. (See Sections 2036-2038-Regulation 2.)

The comprehensiveness and flexibility of the Bay Area approach enhances its effectiveness in resolving odor problems. Its most desireable features include:

- Specificity - The major odorous emissions are specifically governed by emission limitations. Further, Kraft pulp mills and rendering plants are subject to individual performance standards. This specificity adds certainty and predictability to the regulation and allows the agency to focus its resources where they can be most cost-effective. Exemptions are clearly established.

- Flexibility - The regulation preserves nuisance law and provides for general ambient and emission odor standards. These general standards allow the agency to deal with odor problems involving odorants other than the five covered by § 15105 or sources other than Kraft pulp mills or rendering plants.

- Responsive to Community Sensibilities - The complaint-triggering feature of the regulation avoids the dilemma of imposing expensive controls in the absence of a demonstrated community odor nuisance. This should be an important aspect of any odor control program.

- Clearly Written - The Bay Area odor regulation is very well drafted. The provisions are written in a way that can be understood by lay people without loosing technical accuracy. Testing and analysis procedures are clearly spelled out.

- State of the Art Measurement Approach - The Bay Area is one of few major air pollution agencies using the dynamic olfactory method for compliance testing. This approach avoids many of the problems inherent in the use of the Scentometer or the static ASTM approach.

- Enforceability - Agency officials indicate that the regulation has been very effective in resolving odor problems and obtaining compliance. Many sources have been brought into compliance with Division 15 through both formal and informal procedures.

4.9 Summary and Conclusions

Any analysis of alternative federal odor control strategies should begin with a review of State and local experience in the field. The general conclusion that can be drawn is that most agencies, while dissatisfied with exist-

ing regulatory approaches, recognize that technical limitations stand in the way of simple solutions or more effective alternatives. As noted by the APCA TT4 Odor Committee:[2]

> "There has been a definite reluctance expressed by some state and local agencies considering new regulations to incorporate the use of the ASTM syringe method or Scentometer. Instead, they prefer to retain the nuisance concept to regulate odors. Further, those agencies which do specify either of these two odor measurement methods still have an odor nuisance regulation or various criteria for determining an odor to be objectionable. However, the agencies recognize the limitations of the odor nuisance concept.
> "It must be concluded that present odor regulatory approaches are generally unsatisfactory. There are two basic needs: (1) develop sound administrative procedures for confirming the existence of a community odor nuisance, and (2) obtain reliable odor sensory data that can be related to community acceptance or annoyance of a particular odor."

The Committee then goes on to make several specific recommendations for improving the effectiveness of current odor-control regulations. These recommendations are in basic harmony with the expressed thoughts of those agency officials with whom discussions were held during this study and are pertinent to the analysis of future federal involvement in odor pollution control. From the standpoint of this report, the most significant conclusions of the APCA TT4 Committee are:

1. The Committee arrived at an essentially unanimous consensus that the existence of a community odor nuisance should be established before regulatory limits are applied to a specific odor source to obtain compliance. The procedure for establishing a community odor nuisance would require a specific number of valid complaints being received from separate households during a fixed time period. The Committee also concluded that there should be specific procedures and guidelines provided to establish the

existence of a community odor nuisance which take into account the community's characteristics: population distribution, socioeconomic activity, and land use zoning.

2. The Committee agreed that odor problems are basically related to the local community and should be regulated by the appropriate local agency.

3. Based on the technology currently available for measurement and control, limiting the odor dilution ratio of the stack emission is preferred as a method of correcting an odor problem. However, applying rigid limits to stack emissions should be avoided. Flexibility should be provided with some allowance being made to take into account local conditions and type of zoning.

4. The relating of ambient odors to annoyance thresholds for different communities or zoned areas is fundamental to establishing ambient odor type standards. This could be accomplished by determining dose-response relationships that equate annoyance with odor intensity and the degree of unpleasant character of a particular odor.

This is a relatively complex approach to developing odor regulations. However, there is a strong consensus of the Committee that it could prove to be useful as a long-term approach. It would be necessary for the funding of this program to be provided by the Federal EPA as opposed to any state or local agency.

5. It should be clear what specific types of odors and/or sources are to be excluded from the regulations.

6. The Scentometer and ASTM syringe methods currently used by state and local agencies are considered by the Committee to be inadequate for regulatory purposes. There is a basic need for odor sensory methods which are capable of measuring odors objectively and reliably.

   There is a consensus of the Committee in favor of the dynamic olfactometer approach and phasing out of the ASTM syringe method for regulatory enforcement."

Given the basic structure of the Clean Air Act, it would be difficult, if not impossible, for EPA to incorporate many of these recommendations into a federal odor pollution control strategy. This statement is particularly true with respect to the possible promulgation and implementation of national ambient standards under Sections 108-110 of the Act. The next chapter discusses these limitations and analyzes the advantages and disadvantages, as well as the legal-administrative constraints, of the various alternatives available for regulating odors under the Clean Air Act.

5.0 ADVANTAGES AND DISADVANTAGES OF ALTERNATIVE ODOR CONTROL STRATEGIES UNDER THE CLEAN AIR ACT

The ultimate objective of this report is to analyze the implications and limitations of alternative odor control options under the Clean Air Act. The Clean Air Act offers three basic alternatives for controlling non-hazardous emissions: 1) The implementation of National Ambient Air Quality Standards (NAAQS) through State Implementation Plans (SIP's), 2) The promulgation of Federal New Source Performance Standards (NSPS) for designated emissions from specified categories of stationary sources, or 3) The promulgation of Federal standards applicable to emissions from new motor vehicles.

Establishment of NAAQS sets in motion a complex, time-consuming and expensive legal process for implementing and maintaining the standards. Thus, any decision to establish a new ambient standard for odor would be made only after extensive research, analysis and public comment.

Although federal New Source Performance Standards generally have a far smaller macroeconomic impact than NAAQS, they may have significant microeconomic implications for the affected industries. As of July 1979, EPA had established NSPS for 27 stationary source categories.[27] To date, only one category, kraft pulp mills, has been subjected to performance standards concerned primarily with odor (i.e., total reduced sulfur)*.[24] In promulgating this standard, EPA did not attempt to use the subjective ASTM approach. Rather, objective

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*The particulate/opacity standards for sewage treatment plants and petroleum refineries may have an indirect impact on odor emissions.[21]

technology-based numerical emission limitations of a readily measureable material were established as is the mandated approach under Section 111 of the Act.

The remaining sections of this report analyze the pros and cons of regulating odors under the NAAQS and NSPS provisions of the Clean Air Act.

5.1 National Ambient Air Quality Standards

5.1.1 Statutory Overview

Under Sections 108-110 of the Clean Air Act, EPA is authorized to establish national air quality standards for selected "criteria" pollutants. Once the standards are established, the Act requires the states to prepare, adopt and submit an implementation plan to EPA, which provides for the attainment and maintenance of the national standards within the time frames established by the Act. These state implementation plans (SIP's) must include emission limitations, compliance schedules and such other measures as may be necessary to ensure timely attainment and maintenance of the standards. Areas failing to attain the standards by the deadline are subject to the Act's new nonattainment provisions. Areas with air quality better than the standards must prevent significant deterioration of existing clean air.

A decision to regulate a pollutant under Sections 108-110 has major nationwide implications for government, industry and the public. The development of NAAQS implementation strategies is an expensive and lengthy process. In the 9 years since passage of the 1970 Clean Air Act Amendments, seven criteria pollutants have been established. They include sulfur oxides, particulate matter, nitrogen oxides, carbon monoxide, photochemical oxidants, hydrocarbons* and most recently, lead.[28]

The NAAQS-SIP process involves three basic steps. In analyzing whether and how odor pollution should be regulated under this statutory scheme, each

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* The hydrocarbon standard is used only as a guide in assessing the adequacy of oxidant attainment strategies. Under existing regulation it cannot, therefore, be used to control odors per se.

step must be considered separately. The first step involves identification and formal listing by EPA of the "air pollutant" for which ambient standards are to be developed. Having listed the pollutant and published health/welfare effects criteria and control techniques guidelines applicable to it, EPA's next step is to establish primary and secondary national ambient air quality standards. Primary standards represent those concentrations of the pollutant that must be maintained to protect public health. Secondary standards address public welfare.

The third step in the process is the most costly and time consuming: implementation. The Act places primary implementation responsibility on the States to develop and submit implementation plans. These plans must comply with EPA's SIP Guidelines[29] and the Act gives EPA authority to promulgate its own SIP provisions for States submitting inadequate plans.[30] Regardless of who develops the plan however, it must be adequate to attain and maintain the ambient standards, and to prevent significant air quality deterioration in areas where those standards have been attained.

5.1.2 The Listing Process

Section 108 of the Act sets forth three conditions for listing pollutants that will be made subject to ambient air quality standards. The list includes each air pollutant*, emissions of which, in the EPA Administrator's judgment:

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* The Act defines the term "air pollutant" as any air pollution agent or combination of such agents, including any physical, chemical, biological, radioactive (including source material, special nuclear material, and by-product material) substance or matter which is emitted into or otherwise enters the ambient air.[31] This term appears to be broad enough to include "odors' generally or any specific odorant.

1. cause or contribute to air pollution which may reasonably be to endanger public health or welfare;

2. the presence of which in the ambient air results from numerous or diverse mobile or stationary sources; and

3. for which air quality criteria had not been issued before the date of enactment of the Clean Air Amendments of 1970, but for which the Administrator plans to issue air quality criteria under this section.

Within 12 months of including a pollutant on the list, EPA must issue health and welfare effects criteria that accurately reflect the latest scientific knowledge useful in indicating the kind and extent of all identifiable effects on public health or welfare that may be expected from the presence of such pollutants in the ambient air, in varying quantities.*

Clearly, the third condition is the critical determinant in the listing process. No one could deny that odors can pose a threat to public welfare or that they result from numerous and diverse mobile and stationary sources. The decision to issue air quality criteria under Section 108, however, is left to the EPA Administrator's discretion.**

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* Although odor levels and specific health or welfare effects, have not been precisely correlated, similar uncertainties exist for all the existing criteria pollutants.

** Note, however, the courts have held that a § 108 listing is mandatory where, as in the case of lead, EPA has formally found that the pollutant meets conditions "1" and "2". Natural Resources Defense Council v. Train, 411 F. Supp. 864 (S.D.N.Y. 1976), aff. 545 F.2d 320 (2nd Cir., 1976).

Although odors were one of five pollutants originally identified in the Senate's 1970 Clean Air Act deliberations as being of nationwide concern,* EPA has indicated that it does not intend to list odor as a criteria pollutant in the forseeable future.[32]

Conceptually, there are only two ways of listing "odor" as a criteria pollutant under Section 108. The first is simply to lump all odorous compounds together and list "odor" as a criteria pollutant. The second is to identify one or more specific odorous compounds or class of compounds. As will be noted, both approaches would create difficult implementation and enforcement problems.

The listing of "odor" as a criteria pollutant presumes that exposure to any odor of a given intensity or for a specific duration causes adverse effects on health or welfare. Even if one accepts the validity of this premise, current understanding of odor effects does not allow any particular point on an "odor" measurement scale to be correlated with identifiable effects on public health or welfare. Odors vary widely in quality and acceptability at different intensities, frequencies and durations. Human perceptions of odor vary widely between individuals and even for the same individual, depending upon the context and location of exposure. In short, a single standard for all "odors" would create administrative chaos under the Clean Air Act. It would force States to develop strategies for reducing all ambient odor levels, regardless

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* At the time of the passage of the 1970 amendments, air quality criteria already had been issued for five major pollutants (sulfur oxides, particulates, carbon monoxide, hydrocarbons and photochemical oxidants). Other pollutants of broad national impact identified by the Senate Subcommittee on Air and Water Pollution in its report accompanying the bill that ultimately became the 1970 amendments were fluorides, nitrogen oxides, polynuclear organic matter, lead and odors.[33] Of these five candidates, one (nitrogen oxides) since has been listed by the Administrator on his own volition as a criteria pollutant, and one other (lead) has been listed by compulsion as a result of a citizen suit.

of their annoyance threshold, to an arbitrary intensity level. Such reduction would be mandated regardless of whether those odors were annoying anyone.*

It follows that any attempt to list and establish national ambient stanards for odor pollution must focus on specific odorants or classes of odorants. While an identification of such compounds is obviously beyond the scope of this report, existing state and local regulations afford a good starting point for selecting such "criteria odorants." Mercaptans, phenolic compounds, hydrogen sulfide, carbon disulfide, amines, ammonia, and selected esters and fatty acids are the obvious candidates. If a realistic chemical description could be developed for one or two of the most widespread odorant combinations, it might be feasible to promulgate an appropriate ambient standard. Ideally, such a standard would address those odorous compounds or mixtures typically occurring together in the ambient air surrounding a relatively few source categories. One useful approach might be to develop a comprehensive chemical definition embracing the prime odorants attributable to a few source categories which are common source of odor complaints, such as:

1. Rendering, meat packing, slaughter houses.
2. Chemical plastic plants.
3. Sanitary land-fills.
4. Petroleum and natural gas refining and asphalt production.
5. Diesel exhausts.

If a reasonably specific chemical description could be developed, it might then be possible to determine a realistic annoyance threshold value for establishing ambient standards. In the absence of such a description,

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* While a complaint-triggering mechanism is a feasible screening device under state and local odor regulations, the Clean Air Act does not appear to allow such flexibility. The air quality management frame - work of the Act employs standards fixed in terms of allowable concentration levels such as ppm or $\mu g/m^3$.

the sheer number of different odorants, each with unique odor qualities, would clearly preclude an odorant-specific approach to the problem.

5.1.3 Establishing Ambient Standards

Upon the issuance of effects criteria for a listed criteria pollutant, EPA must propose and later promulgate national primary and secondary ambient air quality standards. National primary ambient air quality standards "shall be ambient air quality standards, the attainment and maintenance of which in the judgment of the Administrator, based on (the) criteria and allowing an adequate margin of safety are requisite to protect the public health."* It is clear from the legislative history that the public whose health is to be protected includes "particularly sensitive citizens such as bronchial asthmatics and emphysematics who in the normal course of daily activity are exposed to the ambient environment."[33]

The national secondary ambient air quality standards prescribed under the Act "shall specify a level of air quality the attainment and maintenance of which in the judgment of the Administrator, based on (the) criteria, is requisite to protect the public welfare from any known or anticipated adverse effects."[33] The public welfare that must be protected "includes, but is not limited to, effects on soils, water, crops, vegetation, man-made materials, animals, wildlife, weather, visibility, and climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on

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* The "adequate margin of safety" referred to in the Act was included to protect against potential health hazards not yet identified by research. Presumably the language would justify a health-related standard based upon ambiguous or incomplete data. The Clean Air Act allows the administrative prohibition of certain activities without actual proof of health hazards to an identifiable group, so long as the prohibition can be defended as a scientifically supportable margin of safety.[35]

personal comfort and wellbeing." The reference to "economic values" has been discussed in the literature:

> The reference to "economic values" should be read as authorizing protection from effects of economic significance not otherwise mentioned (such as offenses to aesthetic values) rather than indicating that economically significant effects are the only ones that count. Protecting public welfare from both "known or anticipated adverse effects" affords the environment a margin of safety in the standards, albeit not one as expansive as that extended the protection of public health. The primary and secondary standards, together, are conceived as establishing a minimally acceptable level of ambient air quality protecting man and his environment from all known effects and some that, although not known, are legitimate subjects of concern.[35]

With respect to odors, the reference to property deterioration and personal comfort and wellbeing seems clearly broad enough to include odor pollution.

Conceptually, there are several ways of phrasing an ambient standard for odor pollution. If a sensory approach is adopted, a standard could be based on the following sensory measurement techniques:

1. Objectionability to a trained inspector.
2. A scentometer reading.
3. Other dilution to threshold measurement techniques.

The alternative, as discussed earlier, is to specify a maximum numerical concentration for specified odorous compounds or mixtures.

The difficulties inherent in a sensorybased standard have been discussed in the previous chapter. The wide variation in specific odorants and in people's responses to them makes it impracticable to establish a single standard for all offensive odors.

An objectionability standard, for example, is, by definition, a purely subjective approach. To phrase a national ambient standard in terms of its "objectionability" to a trained investigator is totally incompatible with air quality management orientation of the Act. Concepts such as "attainment," nonattain-

ment," "maintenance" and "prevention of significant deterioration" demand a specific numerical standard by which to measure the success or failure of implementation plans. No matter how many verbal parameters are established to guide the inspector's subjective determinations, precise quantification of ambient conditions is impossible with this approach.

Similarly, the Scentometer approach, through phrased in terms of a quantifield level of odor intensity, is simply too unreliable. As discussed earlier, the APCA TT4 Odor Committee has concluded that the Scentometer is an inadequate tool for purposes of odor regulation. Furthermore, Scentometer readings have no established direct relationship to odor nuisance or annoyance.

The odor sensory panel approach to ambient odor analysis is currently used by the Bay Area Air Quality Management District. This approach involves the collection of a sample of ambient air on or near the owner's property line. This sample is then administered at specified dilutions to a pre-screened odor panel. If over 50% of the panel detects odor in a sample of a specified dilution (usually 4:1), a violation exists.

The odor panel approach, if properly administered, works well under an administrative scheme that responds to odor complaints. It is through the receipt of valid complaints that a potential odor problem is flagged. The feasibility of this approach disappears, however, when one attempts to establish an across-the-board ambient-odor standard regardless of the fact that individuals are not annoyed by atmospheric concentrations that exceed the standard. Since odor detection thresholds, as measured by an odor panel, have no established correlation with odor annoyance thresholds, an ambient standard, based on an odor panel technique would force States to impose odor emission controls regardless of whether or not an odor problem existed.

In this context, it is very important to remember that the fundamental objective of SIP emission regulations is to attain and maintain the national ambient standards. This objective obviously requires an ability to quantify the relationship between changes in pollutant emissions and resulting air quality. On an even more basic level, the ambient standard approach presumes that attainment will protect public health and welfare.

These considerations are pertinent to the decision of whether or not to establish an ambient odor standard. Dispersion modeling techniques for odor are not well-developed. and their use is limited to short distances and to nonreactive odorants. More importantly, as noted earlier, there is insufficient data on which to base a presumption that a given ambient odor level will prevent nationwide community annoyance problems. While the argument can certainly be made that a similarly tenuous ambient concentration-health/welfare link exists for most of the current criteria pollutants, the problem is more significant for odor because the welfare effects that they cause relate to a single perceptual phenomenon.

This is not to say that the secondary (welfare) standards cannot address perceptual insults generally or odors specifically. Clearly, Section 302(h) of the Act defines "welfare effects" with more than sufficient breadth to cover such impacts. From a practical and technical standpoint, however, the difficulty of defining the acceptability of a given odor concentration in quantitative terms severely limits the adaptablity of the NAAQS approach to odor pollution control.

Thus, the most promising approach for the establishment of a national ambient air quality standard for odors would involve the determination of annoyance threshold levels for selected malodorants characteristic of the most ubiquitous odors or most common emissions. Annoyance thresholds differ

from simple laboratory hedonic responses because the thresholds are determined by a population (possibly acclimated) in the context of normal exposure. Such relationships have not been determined to date.

5.1.4 Implementation - Administrative Considerations

No matter how an ambient odor standard might be phrased, several practical considerations cast doubt on the wisdom of promulgating such a standard. The listing and setting of standards is but a prelude to an enormous administrative undertaking aimed toward eventual compliance.

Within 9 months after the promulgation of ambient standards, all States are required to adopt and submit to EPA implementation plans, which provide for the implementation, maintenance and enforcement of the standards.[36] Attainment of the primary (healthrelated) standard must be achieved within 3 years of the plan's approval by EPA. Attainment of the secondary (welfarerelated) standard must be achieved in a "reasonable time."

The development of state implementation plans generally imposes large economic burdens on the government agencies that must prepare them and the air polluting industries that must comply with them. Comprehensive emissions inventories and air quality/meteorologic analyses must be developed, and detailed analyses of alternative emission reduction programs must be completed. Actual implementation involves the expenditure of considerable public and private dollars for administration, hardware controls, plant modifications and other outgrowths of the SIP process.

The 1977 Clean Air Act Amendments, currently being incorporated into the SIP,s by the States, represent a significant increase in the complexity and

economic impact of the NAAQS-SIP program. During 1979, the States must submit plans to EPA for attaining the ambient standards in areas that failed to achieve them by the original deadline[37] and SIP revisions for preventing significant deterioration.[38]

Needless to say, the current SIP revision process is consuming a large fraction of state, local and federal air pollution control attention and resources. Thus, in the absence of some very compelling public health or welfare problem, it seems ill-advised to impose a federal presence in an area that has been traditionally regulated at the state and local level as a nuisance-type problem.

Apart from such practical administrative difficulties, federal ambient odor standards do not appear to represent the most costeffective means of solving odor problems. Odor pollution, unlike most other forms of air pollution, is a problem only to the extent that affected individuals perceive it as a problem. Uniform national standards, even if they could be tied to odor annoyance (and, at present, they cannot) leave no room for variable community sensibilities and preferences. Reactions to odor vary, not only between individuals, but also among different localities. For example, odors that may lead to numerous complaints in a rural or suburban area may go virtually undetected in an urban or industrial setting. It is certainly logical to argue that an odor regulatory strategy should be flexible enough to accomodate such local sensibilities. The NAAQS program does not offer such flexibility.

Finally, and most significantly, the current lack of knowledge concerning odor measurement and modeling would frustrate efforts to implement the air quality management requirements of prevention of significant deterioration and nonattainment. Even if an adequate sensory-based standard could be developed, concepts such as "significant deterioration," "net air quality

benefit" and "baseline air quality" would be extremely difficult to apply to odor pollution. The air quality management framework of PSD and nonattainment are difficult enough to apply to conventional pollutants. Attempts to apply these requirements to a perceptual pollutant such as odor would create potentially insurmountable implementation problems.

5.2 Federal New Source Performance Standards

5.2.1 Statutory Overview

Section 111 of the Act gives EPA the authority to establish standards of performance for new and modified stationary sources.* New Source Performance Standards require emission reductions that reflect that level of control achievable through application of:

> The best technological system of continuous emission reduction which (taking into consideration the cost of achieving such emission reduction, any non-air quality impacts and energy requirements) the Administrator determines has been adequately demonstrated.**[39]

The two most obvious issues raised by Section 111 are the extent to which cost must be taken into account and the extent to which an "adequately demonstrated" system must have proved itself through actual operation.

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* A 'modified' source is one that undergoes a physical or operational change with causes new or increased air pollution. A 'new' source is one which commences construction after NSPS regulations applicable to that source are proposed.[40]

** Once the standard is set, the owner or operator need not use the control system identified by EPA, but the system used must achieve the standard. Normally, installation and operation of a particular control system is not enough; compliance is based on acutal emissions. Only where it is not feasible for EPA to establish a numerical emission standard (e.g., petroleum storage vessels), may the agency establish NSPS requiring specified design or control techniques. In all other cases, the standard must reflect a quantified level of emissions from the control system.

It is not enough that the prototype system be adequately demonstrated and the cost justified. The Act also requires that the standard actually promulgated be an "achievable standard" and one "which is within the realm of the adequately demonstrated system's efficiency". While such a standard may not be set at a level that is purely theoretical or experimental, it need not necessarily be routinely achieved within the industry prior to its adoption.[41]

The Act requires EPA to establish standards for those categories of stationary sources that have a significant impact on air pollution. Although this definition conceivably could apply to all odor sources and, indeed, every industrial sector of the economy, as of July 1979, EPA had established NSPS's for 27 categories of stationary sources covering a limited number of pollutants.

In addition to requiring performance standards for new and modified stationary sources, Section 111 also requires the states to adopt performance standards for "designated pollutants" from certain existing sources under Section 111(d). A "designated" pollutant is one which is subject to NSPS but which has not been listed as "hazardous" under Section 112 of the Act or which is not listed as a criteria pollutant under Section 108.

If EPA promulgates an NSPS for a designated pollutant from new sources of a specific source category, an emission standard must be established by the States governing emissions of that designated pollutant from all existing sources within that category. Fluorides from phosphate fertilizer and aluminum plants,[27] sulfuric acid mist from acid plants,[27] and total reduced sulfur compounds from kraft pulp mills[24] have been regulated under the authority of Section 111(d). Rendering plant standards have been considered but have never been proposed, since odor measuring abilities have been

deemed inadequate for fair enforcement and since standards for other pollution sources offered a greater opportunity for improving ambient air quality.

Promulgation by EPA of standards limiting emissions of odorous materials from motor vehicles can be considered as a specialized type of New Source Performance Standard for the purposes of this report. Section 202 of the Clean Air Act provides EPA with the basic authority to establish standards applicable to new manufactured motor vehicles and motor vehicle engines. These standards require the manufacturer to demonstrate compliance with prescribed emissions limits for prototype vehicles or engines operated for extended periods before he is eligible to receive a certificate allowing him to proceed with sale of the vehicle or engine to the general public. To establish such standards, EPA must show that technology is available to permit compliance at reasonable costs* and that suitable methods of measurement exist for the material regulated. At this time, no odor standards applicable to motor vehicles are under development. Consideration has been given in the past to odor standards applicable to heavy duty diesel engines designed for trucks and buses. At the present time, however, it appears that the state of the art in the design of heavy duty motor vehicle engines has advanced to the point where new and well maintained engines of these types are not objectionable sources of urban odors. Thus, in this report, no further consideration will be given to the regulation of odors under the provisions of Section 202 of the Clean Air Act.

It should be added that poorly maintained vehicles that are powered by catalyst-equipped gasoline engines or by diesel engines can produce odors under some circumstances.

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*Except for three of the pollutants covered by NAAQS's: HC, CO and NO_x

TABLE 3. PRIORITIZED MAJOR SOURCE CATEGORIES FOR NEW SOURCE PERFORMANCE STANDARD (NSPS) DEVELOPMENT

Priority	Source category
1*	Synthetic Organic Chemical Manufacturing Industry (SOCMI)
	(a) Unit processes
	(b) Storage and handling equipment
	(c) Fugitive emission sources
	(d) Secondary sources
2	Industrial surface coating: cans
3*	Petroleum refineries: fugitive sources
4	Industrial surface coating: paper
5	Dry Cleaning
	(a) Perchloroethylene
	(b) Petroleum solvent
6	Graphic arts
7*	Polymers and resins: acrylic resins
8	Mineral wool
9	Stationary internal combustion engines
10	Industrial surface coating: fabric
11	Fossil-fuel-fired steam generators: industrial boilers
12	Incineration: non-municipal
13	Non-metallic mineral processing
14	Metallic mineral processing
15	Secondary copper

*Designates a significant odor source.

Table 3 (Cont.)

Priority	Source category
16	Phosphate rock preparation
17	Foundries: steel and gray iron
18	Polymers and resins: polyethylene
19	Charcoal production
20*	Synthetic rubber
	(a) Tire manufacture
	(b) SBR production
21	Vegetable oil
22	Industrial surface coating: metal coil
23	Petroleum transportation and marketing
24*	By-product coke ovens
25	Synthetic fibers
26	Plywood manufacture
27	Industrial surface coating: automobiles
28	Industrial surface coating: large appliances
29*	Crude oil and natural gas production
30	Secondary aluminum
31	Potash
32	Sintering: clay and fly ash
33	Glass
34	Gypsum
35	Sodium carbonate
36	Secondary zinc

*Designates a significant odor source.

Table 3 (Cont.)

Priority	Source category
37*	Polymers and resins: phenolic
38	Polymers and resins: urea-melamine
39*	Ammonia
40	Polymers and resins: polystyrene
41	Polymers and resins: ABS-SAN resins
42*	Fiberglass
43	Polymers and resins: polypropylene
44*	Textile processing
45*	Asphalt roofing plants
46	Brick and related clay products
47	Ceramic clay manufacturing
48*	Ammonium nitrate fertilizer
49	Castable refractories
50	Borax and boric acid
51*	Polymers and resins: polyester resins
52	Ammonium sulfate
53	Starch
54	Perlite
55	Phosphoric acid: thermal process
56	Uranium refining
57	Animal feed defluorination
58	Urea (for fertilizer and polymers)
59	Detergent

*Designates a significant odor source.

Table 3 (Cont.)

Other Source Categories

Lead acid battery manufacture[1]

Organic solvent cleaning[1]

Industrial surface coating: metal furniture[1]

Stationary gas turbines[2]

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[1]Minor source category, but included on list since an NSPS is being developed for that source category.

[2]Not prioritized, since an NSPS for this major source category has already been proposed.

5.2.2 Impact of the 1977 Clean Air Act Amendments

The 1977 Clean Air Act Amendments made several important changes to Section 111. Some of these changes are quite relevant to the issue of NSPS for odor sources even though odor control may not be the prime consideration for regulation development. Two of the most significant changes are:

1. Expansion of NSPS Coverage[39]

The new Act directs EPA to greatly expand the coverage of NSPS program between 1978 and 1982. Specifically, EPA was directed to list all stationary source categories which had not been made subject to NSPS when the amendments were enacted. This list was published on August 21, 1979 (44FR49222). The final prioritized list as amended following public comment is reproduced in Table 3. By August 1980 standards must be promulgated for 25% of the categories identified. By August 1981, standards must be promulgated for 75% of the listed categories, and by August 1982, standards must be established for the remaining 25%.

Several of the listed sources could cause significant odor problems in many areas, if uncontrolled. Table 3 denotes these sources with asterisks. As an added benefit of these regulations, reduction of emissions of odorants from these source categories should produce significant odor reduction benefits from existing sources in the affected category as they are required to control those "designated" odorants pursuant to Section 111(d) of the Act. Although not designed as an odor control strategy, the promulgation of New Source Performance Standards (NSPS's) will have the effect of reducing odorous emissions from a variety of important odor sources.

2. Dispersion Techniques Not An Acceptable Method of Compliance[40]

The Amendments clarify that neither intermittent or supplemental controls (those varying with meteorological conditions) nor dispersion techniques (e.g., tall stacks) may be used as a means of compliance with NSPS. The new law specifies that the required emission reduction strategy must be a technological system of continuous control.[40]

The dispersion limitation has a rational basis in the context of criteria pollutants with known or suspected health effects. Congress has decided that

for these pollutants, control requirements must reduce total atmospheric loading as opposed to allowing compliance through improved atmospheric dilution. Applying this limitation to odors may not be appropriate, however, since the ultimate objective of any odor emission limitation is to eliminate odor nuisances rather than to protect public health. Dispersion techniques and supplemental control systems frequently represent an effective and economical means of accomplishing this basic objective.

5.3 Conclusions

While new source performance standards and designated pollutant standards under Section 111 appear to offer more promise than ambient standards as a federal odor control strategy, technical difficulties still exist. The fundamental problem is that applying best available control technology does not guarantee that community odor annoyance levels will not be exceeded. This problem becomes even more complicated when fugitive odor sources such as lagoons are involved or when multiple odor sources are located in close proximity to one another. These factors make it nearly impossible to estimate the "odor impact" of any particular source or to predict the odor reduction potential of any given abatement program.

Despite these difficulties, federal new source performance standards for selected odor sources may be an approach to solving some existing and avoiding many future odor problems that should be carefully considered. A well focused approach would avoid "federalizing" the odor pollution field, while substantially reducing odor emissions from those source categories that are most frequently the cause of complaints.

6.0 GENERAL CONCLUSIONS

With the current state of odor pollution technology, each of the regulatory approaches available under the Clean Air Act is beset by technical uncertainties and varying social preferences toward odors, which tend to undermine a national regulatory program.

Unambiquous evidence demonstrating adverse health effects of odors has not been established. Although it is recognized that exposure to odorants can produce such symptoms as nausea, anorexia, or sleeplessness, there are no definitive data relating odor exposure to these responses. Therefore, the available data are insufficient to support establishing a primary ambient air quality standard for odors.

A similar problem would be encountered in attempting to develop welfare-based ambient air quality standards. Subjective reactions to odors vary between both individuals and communities and are highly dependent upon the context in which the odor is perceived. At the present time, it is not possible to predict community annoyance from the measured sensory or analytical properties of odors. Methods are available for determining community annoyance, but these methods have not as yet been correlated with sensory or analytical measurements of ambient odor levels. Without reliable data relating ambient odor levels to community annoyance, it would be difficult to devise an ambient air quality standard for odors that would ensure the protection of the public welfare without imposing unnecessarily stringent controls on odor emission sources.

There are additional technical and administrative implications associated with establishing National Ambient Air Quality Standards for odors.

First, odorants and their odors vary widely in character and acceptability at different intensities, frequencies, and durations. It follows that it is not possible to set a single ambient air quality standard for all offensive odors. On the other hand, the sheer number of different odorants, each with unique odor properties, hinders an odor specific approach to the problem.

Second, the establishment and implementation of ambient air quality standards is a resource-intensive process and may not represent the most cost-effective means of solving odor problems.

Third, the current lack of knowledge concerning odor measurement and the application of dispersion modeling to establish levels of significant concern for odors would tend to impede the ability of States to implement National Ambient Air Quality Standards for odors. In many cases, odor detectability levels or odor annoyance thresholds exceed the analytical sensitivities of readily available pollution measurement devices. Also, existing dispersion models are inadequate to predict the impact of alternative odor abatement strategies on ambient odor levels, particularly in areas close to several industrial emission sources.

Finally, uniform National Ambient Air Quality Standards leave no room for variable community preferences. Reactions to odors are dependent upon local values and aesthetics. It can be argued that an odor regulatory program should be flexible enough to accommodate local sentiments on this issue. The NAAQS program does not offer such flexibility.

Regulating odor pollution through New Source Performance Standards would avoid many of the problems inherent in the ambient air quality standard approach. Because the majority of odor problems are attributable to a relatively small

number of source categories, this approach appears to offer a more cost-effective means of odor control than establishing a NAAQS program for odors. This approach would allow regulatory agencies to focus their resources on problem sources without having to expend massive efforts in the monitoring of ambient odor levels or in devising detailed control strategies.

The primary drawback to controling odor problems through New Source Performance Standards is that emission controls for NSPS are not required to be correlated with the impacts on ambient air quality. Instead, these regulations are only required to reflect a level of control equivalent to the best available control technology (with costs and other non-air quality factors considered), which has been adequately demonstrated. Because some odorants can persist in causing annoyance at very low concentrations, NSPS's will not necessarily ensure that odor annoyance is sufficiently abated. The overall effectiveness of NSPS's in controlling odors is also reduced by the fact that fugitive sources are hard to identify and assess and that multiple sources of odors may combine to produce unacceptable effects.

To date, EPA's application of New Source Performance Standards to the control of odor pollution has been limited. In accordance with the Clean Air Act Amendments of 1977, however, EPA has greatly expanded the list of stationary source categories subject to NSPS's. A number of these newly listed sources are known to cause significant odor problems in many areas. Establishing NSPS's for these source categories is expected to produce significant odor reduction as a secondary benefit.

In the final analysis, the basic structure of the Clean Air Act makes it difficult to tailor odor regulations to the needs and sensibilities of our nation's local communities. Therefore, it is concluded that specific

federal odor regulations are not warranted. However, it appears that federal involvement, in the form of research assistance to develop the knowledge required to effectively administer local control programs, may be desirable.

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APPENDIX

CONCLUSIONS OF THE NATIONAL ACADEMY OF SCIENCES REGARDING ODOR MEASUREMENTS

(1) Odorous emissions and odorous ambient air exhibit various analytical and sensory properties. Knowledge of the numerical values of some of these properties is essential to control of the odorous pollution.

(2) Analytical properties of the odorous emissions or odorous ambient air are characterized by the chemical identities and concentrations of the odorants present.

(3) Sensory properties of odorous emissions or odorous ambient air consist of (a) perceived odor intensity, (b) change in intensity with dilution, (c) odor detectability including odor detection and recognition thresholds, (d) odor character, and (e) hedonic tone, which refers to the pleasantness/unpleasantness of the odor.

(4) A determination of the sensory properties of odors from the analytical data on the odorous samples in most cases is not yet possible.

(5) Various methods are available for measurement of analytical and sensory properties of odorous emissions and odorous ambient air, but we do not know how to apply them.

(6) A limited amount of information is available on the performance of the various measurement methods but is nonetheless sufficient for a preliminary selection of those which are most suitable and appropriate for a further development; in particular, needs exist for a more comprehensive investigation on their reproducibility, means of improving the reproducibility, and applicability of various types of emissions and ambient air odors.

(7) The methodology for estimating the impact of ambient odors is not well developed.

(8) The existing odor control regulations, wherever they are quantified in terms of some odor property, almost exclusively prescribe some form of odor detection threshold measurement as a basis for determining the severity of the odorous pollution; by far the most dominant are the ASTM D-1391 Syringe Dilution and the Scentometer methods. The present state-of-the-art of odor measurement technology is capable of providing methods that are free from several shortcomings of these two methods and can supply more useful information on pollution odors, especially on the dose/response function for specific odors.

(9) Significant factors in odor measurements of emissions and ambient air are (a) techniques of the sample acquisition, (b) sample storage, if any, (c) selection of the most appropriate analytical or sensory property to be measured, (d) selection of a practical method for measuring this property in an easily standardizable way, and, in the case of sensory measurements, selection of procedures essentially free from various specific effects inherent in the sensory evaluations, and (e) performance of the specific methods, especially with respect to the reproducibility of results when identical odorous samples are evaluated by different working groups.

(10) Unless all factors affecting the values of odor thresholds are standardized, widely different odor thresholds are likely to be reported for the same samples by different groups. Until then, data obtained by the same system, preferably by the same panelists, can be utilized in monitoring of the efficiency of odor control on a relative basis.

(11) A single odor threshold value does not exist; it is a function of measurement method variables and may be defined only by reference to specific measurement systems. There may be a functional "true" value based on the detection or recognition threshold of an odor in free ambient air, entering such air from an essentially non-odorous environment; if this value for the particular odor were known, the odor measurement system that produces the threshold value closest to such hypothetical true value, either directly or through some calibration plot, would be a preferred odor threshold measurement system. Work in this direction in open air is unknown.

(12) The hedonic tone (pleasantness/unpleasantness) is widely recognized as a very important factor in determining the relative annoyance potential of the odorous pollution. Limited experience demonstrates that measurement of hedonic tone produces correlated results when performed in different laboratories on similar sets of odorants. A broadly accepted hedonic sample reference scale does not yet exist, but appears feasible. The relation between the hedonic tone and the annoyance that results when the same odor is encountered in the context of odorous pollution is poorly understood, especially for pleasant odors.

(13) Analytical measurements are applicable to monitoring the content of specific odorants in emissions and in ambient air. In a few cases where partial correlations have been found between the odor threshold or odor intensity of the odorous samples and the content of specific odorants, the analytical measurements can be a valid tool for monitoring the state of odor control. Analytical data may assist in relating an ambient odor to its possible sources and in verifying atmospheric dispersion models. In most odor pollution cases, many odorants are present and analytical data cannot substitute for sensory data.

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16. ABSTRACT

This report was prepared in response to Sec. 403b of the Clean Air Act Amendments of 1977. Together with "Odors from Stationary and Mobile Sources" prepared by the National Academy of Sciences it constitutes the Report to Congress of EPA.

This report surveys current State and local odor regulations, evaluates the effectiveness of regulations similar in form to those that might be promulgated under the Clean Air Act, and then discusses the advantages and disadvantages of alternative Clean Air Act regulatory strategies.

The report concludes that federal regulatory involvement in odor control does not appear to be warranted at this time.

17. KEY WORDS AND DOCUMENT ANALYSIS		
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